A NEW MONOSTOME TREMATODE PARASITIC IN THE MUSKRAT WITH A KEY TO THE PARASITES OF THE AMERICAN MUSKRAT*

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Introduction

In studying the parasites of muskrats shot on Lake Chisago, Minnesota, last summer (August, 1915), in addition to several species previously reported for muskrats Barker (:15, p. 184) more than a hundred specimens of a small monostome trematode heretofore unrecorded for the muskrat were found in one male animal.

Morphology

To the unaided eye the trematodes appear as very small, thick ovals or globules, milk white in color. The length varies from 0.709 to 0.899 mm., the breadth from 0.501 to 0.657 mm. Under the hand lens or binocular the anterior third or fourth of the body is seen to taper gradually. The posterior third of the body also tapers slightly, but the end is markedly truncate. A rather wide but shallow indentation is fairly constant on each side in the region of the middle third of the body, and the body is widest just anterior to this constriction. A slight, wide but shallow, indentation also occurs in the center of the posterior end of the body, which marks the outlet of the excretory vesicle. The dorsal surface of the body is strongly convex in both diameters; the ventral surface is concave or cupped.

The lateral and posterior margins of the body turn ventrad and mesad forming a ventral horse-shoe-shaped shelf one-fifth to one-

*Contributions from the Zoological Laboratory of the University of Nebraska, No. 115.

fourth the width of the body. The anterior fifth of the body is often strongly flexed ventrad, this flexed condition together with the ventral shelf forms a characteristic elongated ventral cavity or cup-like groove which undoubtedly functions as an effective holdfast in lieu of an acetabulum, which is absent in this form. The ventral groove is wide and shallow anteriorly and narrow and deep posteriorly. In some specimens the anterior end of the body is straightened out obliterating the cavity at that end. The posterior end likewise may be straightened, thereby breaking the continuity of the shelf and altering the shape of the ventral depression. Ventral papillæ or ridges are entirely absent and the body is devoid of spines or spinelets.

Digestive tract: Only one sucker, oral in position is present. It is slightly sub-terminal, quite muscular, circular or oval in shape and measures 0.05 to 0.06 mm. long by 0.052 to 0.065 mm. wide. The esophagus is straight and about twice as long as the diameter of the oral sucker. A pharynx is absent. The intestinal caeca lie in the median third of the body, and are slightly undulating but without pockets. Their course is nearly straight to the posterior half of the body where they make a decided wide outward bend, but in the posterior fifth of the body they again turn medianward and approach each other but remain separated by a median space equal to about four times their diameter. Both caeca end blindly in the posterior eighth of the body.

Genitals, female: The ovary lies in the extreme posterior end of the body, just to the left of the median line and dorsal to the left testis. Its bulk lies between the posterior ends of the testes, but a small portion overlaps one testis. The ovary is elongated and somewhat convoluted or twisted and the convolutions do not all lie in the same plane which gives a lobed or segmented appearance to the organ in any one plane of focus. The oviduct arises from the internal lobe of the ovary and almost immediately penetrates the shell gland and emerging as the uterus proceeds with several coils anteriorly and to the left around the base of the cirrus pouch. It then passes transversely across the entire body of the worm and in increasingly larger ascending transverse coils extends anteriorly to the level of the bifurcation of the digestive tract, then descend-

ing in wide transverse folds or coils to the level of the cirrus pouch again it passes posteriorly in a sharp right angle turn around the base of the pouch and merges with the vagina. The vagina is narrower than the uterus and lies just posterior to and parallel with the cirrus pouch. The lumen of the terminal third of the vagina is widened and its wall wrinkled affording considerable expansion for the reception of the unusually large thick cirrus. The vagina terminates externally in a large opening the vulva, or female genital pore, slightly posterior and to the left of the opening of the cirrus pouch. The lumen of the terminal portion of the vagina is lined with thick cuticula and surrounded by two muscular sheets, one of longitudinal and one of circular muscle fibers. This muscular wall is in turn surrounded by a large oval mass of gland cells. In many specimens the lumen of the vagina and the contiguous transverse descending arm of the uterus are filled with sperm cells. The vitellarium consists of two compact convuluted tubular masses extracæcal in position, one lying on each side of the body in the middle third. From the posterior portion of each gland a transverse vitelline duct passes posteriorily and mesad and enters a small but definite oval vitelline reservoir median in position and lying between the fourth and last posterior fifths of the body just anterior to the shell gland. Neither a Laurer's canal nor a receptaculum seminis were found.

The shell gland lies in the median plane of the posterior fifth of the body between the testes. It is triangular in shape, fairly large, and well defined, tho not prominent. The oviduct passes thru the center of its mass, the cells of which are arranged in a characteristically radiating manner around the lumen of the oviduct.

Eggs: The eggs are very numerous, of a light straw color, oval in shape and about twice as long as wide. The length varies from 0.02 to 0.024 mm., and the breadth from 0.010 to 0.013 mm. A well defined operculum or lid is present at the narrower end of the egg. At each pole the shell substance is drawn out into a very long solid tapering filament. Each polar filament is often five times as long as the egg proper. The filaments of the eggs *in utero* intertwine forming tenacious strings of eggs which can withstand considerable tension. The manner in which these long polar filaments

are formed in the moulding of the egg shell offers an interesting problem.

Genitals; male: The two large testes are lateral in position, extracæcal, one lying on each side, in the posterior third or fourth of the body. They are solid oval or longated bodies longer than wide and are frequently two to five lobed. Their entire mass does not lie in the same vertical plane of the body. The left testis is generally larger than the right one. From each testis a short transverse vas efferens runs medianward, the two uniting to form a wide tubular convoluted seminal vesicle having its base in the median plane at the level of the anterior margin of the shell gland. From this point it passes forward turning to the right around the base of the cirrus pouch which it enters from the dorsal surface. The cirrus pouch is comparatively very large, its length being one-third to one-half the width of the body and lies transversely across the median portion of the body at the anterior level of its posterior half. It is pear-shaped with its base to the right. The base contains an enlargement of the seminal vesicle which is surrounded by the cells of the prostate gland. The middle portion and neck contain the large thick cirrus. The lumen of the cirrus is markedly eccentric, lying nearer the under or ventral surface, and is lined with a thick cuticula. Internal to this lining is a single sheet of longitudinal fibers which aid in the retraction of the cirrus. The bulk of the cirrus is composed of parenchyma tissue and its musculature is poorly developed. No cirrus spinelets are present. The extruded cirrus is always markedly flexed or curved.

Excretory system: A slight depression occurs in the middle of the posterior end of the body and in the center of this depression is a small excretory pore. A very short canal lined with cuticula and surrounded by a row of radiating gland cells connects the pore with a small stellate shaped excretory vesicle or reservoir. From the reservoir four to eight fine radiating canals lead off in all directions and planes. The excretory tubules immediately branch and rebranch, soon becoming so attenuated as to make it impossible to follow their course.

Systematic Discussion

Kossack (:11, p. 553) in a thoro revision of the monostome trematodes, groups the five heretofore recognized families in two families, the *Cyclocœlidæ* and the *Notocotylidæ*. He clearly points out that the *Notocotylidæ* differ essentially from the other families of monostomes with respect to the following striking characters: the absence of an acetabulum; the presence of ventral glands (drüsenpakete); the absence of a pharynx; the position of the extracæcal testes and the intercaecal ovary in the same plane in the extreme posterior end of the body; the elongated vagina and cirrus sac, which incloses a part of the much convoluted seminal vesicle; the strongly developed vitelline glands lying lateral to the intestinal cæca in the posterior half of the body; the absence of a receptaculum seminis; the uterine coils posterior to the cirrus pouch, and the presence of a polar filament at each end of the egg.

Lühe, (:09, p. 33) created a new genus *Paramonostomum* to contain *Monostomum alveatum Mehl. Paramonotomum alveatum* Lühe, conforms to the diagnostic characters of the *Notocotylidæ* with the exception of the presence of ventral glands, which both Lühe and Kossack report they were unable to find either in toto preparations or in sections.

We seriously question the validity of creating a new genus for this species on a single important differentiating character, namely the absence of ventral glands. The number of rows of these ventral glands varies from two in *Notocotylus diserialis* Ssinitzin to three in *Notocotylus triserialis* Diesing and five in *Notocotyle quinqueseriale* Barker and Laughlin and their complete absence in a species might naturally be expected. Their absence then, it seems to us is of specific rather than generic import.

Linton (:10, p. 69) has described a new species representing a new genus of monostomes which he found in three species of tropical fishes. As described by Linton the characters of this new species tally with the characters given for the *Notocotylidæ* with the following exceptions: ventral glands are absent; "the genital aperature is on the left margin approximately at the anterior third of the body;" "the cirrus pouch is relatively large," and a seminal vesicle is present lying "anterior and dorsal to the ovary."

The monostome which we have described has a number of the diagnostic characters of the *Notocotylidæ* such as, the absence of a pharynx; the caudal and parallel position of the extracæcal testes and the ovary; the strongly developed and laterally placed vitelline glands and the eggs with long polar filaments. On the other hand it differs essentially from all of the described species of *Notocotyliadæ* in the absence of ventral glands, with the exception of *Paramonostomum alveatum;* the posterior position of the cirrus pouch, vagina and genital pores; the shape and large size of the cirrus and pouch; the position of the uterine coils anterior to the cirrus pouch, and the compact convoluted vitelline glands. Notwithstanding these differences it obviously more closely resembles the *Notocotylidæ* than the *Cyclocœlidæ*. The question immediately arises as to what characters and what combination or complex of characters must be present in a species to rightly place it in the family *Notocotylidæ*. As Kossack aptly remarks "Man ist bei der Schaffung des Trematoden—systems induktiv vorgegangen." It is often difficult to determine what morphological characters are of real phylogenetic import and therefore afford a reliable basis for a natural classification and what characters are due possibly to environment and therefore may be expected to vary and can not be relied on in determining the true systematic position of a given species. It seems to us that such a complex of characters as the absence of a pharynx; the posterior position of the testes and ovary in the same transverse plane with the testes extracæcal and the ovary situated between them and the presence of polar filaments on the eggs may be considered of real phylogenetic significance and for this reason we do not hesitate to place this new species in the family *Notocotylidæ*. Kossack (:11, p. 554), divides this family into the two sub-families *Notocotylinæ* and *Ogmogasterinæ* on the difference in the character or arrangement of the ventral glands. In the *Notocotylinæ* they are in rows (Reihen Drusenpakete), in the *Ogmogasterinæ* the glands are arranged along long ribs ("Längsrippen, auf denen Drüsenpakete ausmünden"). We agree with Kossack that such a division is well founded and further propose the creation of a third sub-family to contain such species as those described by Linton and the present paper and others that may be found later which have the general character complex of the *Notocotylidæ* but differ from the

two recognized sub-families with respect to particular characters such as the position of the genital pore; the character of the cirrus; the nature and extent of the vitelline glands and the uterine coils and the absence of ventral glands. For this new sub-family we propose the name *Nudacotylinæ* (devoid of cups) and designate the following characters as diagnostic.

Sub-family Nudacotylinæ

Small *Notocotylidæ,* with thick bodies and without ventral glands. Ventral surface may be strongly cupped. Genital pore lateral (to right or left of median line) decidedly posterior to the intestinal bifurcation. Cirrus pouch large, thick, pear-shape, enclosing a small portion of a convoluted winding seminal vesicle. Vitelline glands strongly developed, compact convoluted masses, extracæcal and lateral in the posterior half of the body.

Uterus strongly developed, transverse folds extend laterally over the intestinal cæca and lie anterior or posterior to the cirrus pouch. Eggs with long polar filaments.

Type genus: *Nudacotyle,* mihi; other genus, *Barisomum* Linton. As the type species of the genus *Nudocotyle* we designate the form described in the present paper which we have named *Nudocotyle novicia.*

KEY TO THE PARASITES OF THE AMERICAN MUSKRAT

Body flat, unsegmented III
Body flat, segmented II
Body cylindrical, unsegmented I

I. Body differentiated into long slender region and shorter thicker region 2
1. Body not differentiated into two regions. Body stiff, opaque; mouth surrounded by prominent lips..... b
a. Body thread-like; mouth not surrounded by prominent lips.
(1) Body hair-like (capillary): male with small bursa and single long spicule; eggs with polar plugs.....
.....*Capillaria ransomia* (Barker, 915: 197)
(2) Body thread-like; male with well developed bursa and two short spicules; eggs without plugs.....
.....*Trichostrongylus fiberius* (Barker, 1915: 196)
b. Body stiff, opaque; mouth surrounded by three prominent lips
.....*Ascaris* sp.[1]
2. Body stiff, opaque, divided into long slender cephalic region and shorter, thicker body region.....
.....*Trichuris opaca* (Barker, 1915: 195)

Species inquirendæ.

Filaria sp. (in collection of Bureau of Animal Industry, Washington, D. C.)

II. Found in cysts; in liver..... 2
Not in cysts; in intestine..... 1
1. (1) Body thin, flabby; genital pores unilateral; single row of hammer-shaped hooks on rostellum; three large testes present .....*Hymenolepis evaginata* (Barker, 1915: 194)
(2) Body thick, stiff; genital pores alternate; double row of long and short hooks on rostellum; testes numerous.....
.....*Anomotænia telescopica* (Barker 1915: 194)
2. Bladder-like cysts in liver.....
Cysticercus fasciolaris (Stiles and Hassall, 1894; Linton, 1915: 46)

III. Two suckers, oral and acetabular, present..... 2
One sucker, oral or caudal, present..... 1
1. Oral sucker not present..... B
Oral sucker present..... A
A. Ventral papillæ absent..... b
Ventral papillæ present..... a
a. (1) Three longitudinal rows of ventral papillæ present.....
.....*Catatropis filamentis* (Barker, 1915: 190)
(2) Five longitudinal rows of ventral papillæ present..*Notocotyle quinqueseriale* (Barker and Laughlin, 1911: 261)

[1]Unpublished research by Bessie Noyes.

b. (1) Body thin, spatulate.....
.....*Monostomum affine*[2] (Leidy, 1858: 110-112)
(2) Body thick, ventral aspect cupped.....
.....*Nudacotyle novicia* (the present paper)
B. Caudal sucker present
(1) Testes branched. *Cladorchis (Stichorchis) subtriquetrus*= *Amphistomum subtriquetrum*[3] (Leidy, 1888:126-127)
(2) Testes slightly lobed.....
.....*Wardius zibethicus* (Barker, 1915: 192)
2. Body divided into cephalic and caudal regions..... B
Body not divided ..... A
A. Oral sucker surrounded by collar, bearing spines..... b
a. Oral sucker without collar.....
.....*Plagiorchis proximus* (Barker, 1915: 192)
b. Eggs numerous ..... bb
aa. Eggs few (30 to 100).....
.....*Echinoparyphium contiguum* (Barker, 1915: 187)
bb. Body 3 to 8 times longer than wide..... bbb
aaa. Body 10 to 15 times longer than wide.....
.....*Echinostomum coalitum* (Barker, 1915: 185)
bbb. Uterine coils definitely transverse..... bbbb
aaaa. Uterine coils compact.....
.....*Echinostomum callawayensis* (Barker, 1915: 188)
bbbb. (1) Anterior testis immediately behind the shell gland...
.....*Echinostomum armigerum* (Barker, 1915: 189)
(2) Anterior testis separated from shell gland.....
....*Echinostomum echinatum* (Leidy, 1888: 126-127)
B. Body divided into cephalic and caudal regions.....
.....*Hemistomum craterum* (Barker, 1915: 191)

[2]We question the correctness of the identification of this species and surmise that it is a species of Notocotyle.

[3]The identification of this species is questionable and we surmise that it is *Wardius zibethicus*. We wish to express our thanks to Doctor Joseph Leidy, Jr., for his efforts to secure for us the original material of Professor Leidy and regret that it has been misplaced or destroyed and is not available for comparative study.

Summary

1. A new species of monostome trematode, *Nudacotyle novicia*, from the intestine of the American muskrat is described with four figures.
2. The suggestion is made that *Paramonostomum alveatum* Lühe rightly belongs in the genus *Notocotyle*.
3. A new sub-family, *Nudacotylinæ* is created under the *Notocotylidæ* with *Nudacotyle novicia* as the type genus and species.
4. A key to the parasites of the American muskrat is given.

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Explanation of Plate XXV

Fig. 1.—*Nudacotyle novicia* Barker, free hand drawing of unstained and uncompressed specimen, ventral aspect, under binocular. OS, oral sucker; C, cirrus, extruded; GP ♂, genital pore, male; GP ♀, genital pore, female; S, ventral shelf; VC, ventral cup.

Figs. 2 and 3.—Eggs of *Nudacotyle novicia.* P, polar filament; Op, operculum.

Fig. 4.—*Nudacotyle novicia* Barker, camera lucida drawing of stained and slightly compressed specimen, dorsal aspect. CP, cirrus pouch; ES, esophagus; Ex, excretory reservoir; GP ♂, genital pore, male; GP ♀, genital pore, female; I, intestine; Ov, ovary; OS, oral sucker; SG, shell gland; SV, seminal vesicle; T, testis; Ut, uterus; VG, vitelline gland; VD, vitelline ducts; VR, vitelline reservoir.